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The Merrillville White Pine *(Pinus Strobus)* Bog, Lake County, Indiana

ALVA J. LINDSEY

Preliminary Fossil Pollen Analysis of the Merrillville White Pine Bog

ALVA J. LINDSEY

A Statistical Study of a Beech-Maple Association at Turkey Run State Park, Parke County, Indiana

MABEL M. ESTEN

Book Reviews

These papers are contributions No. 41, 42 and 43, respectively, from the botany laboratories of Butler University. Address all communications regarding them to Butler University Botanical Studies, Butler University, Indianapolis, Indiana, U. S. A.

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THE MERRILLVILLE WHITE PINE (PINUS STROBUS) BOG, LAKE COUNTY, INDIANA

By ALVA J. LINDSEY

The Merrillville bog is located one mile east of Merrillville, Indiana, in the extreme eastern part of Lake county, and about one-half mile north of State Road 30.

This bog was originally a morainic lake of the "kettle" hole variety (9). It is now near the close of hydrarch succession (4) but has not yet reached its climax stage. The one-time lake basin is now filled with twenty-five feet of peat, which is covered with a dense herbaceous and woody vegetation. The surface of the bog is dry except during wet seasons. During August, 1931, the water table was four feet from the surface.

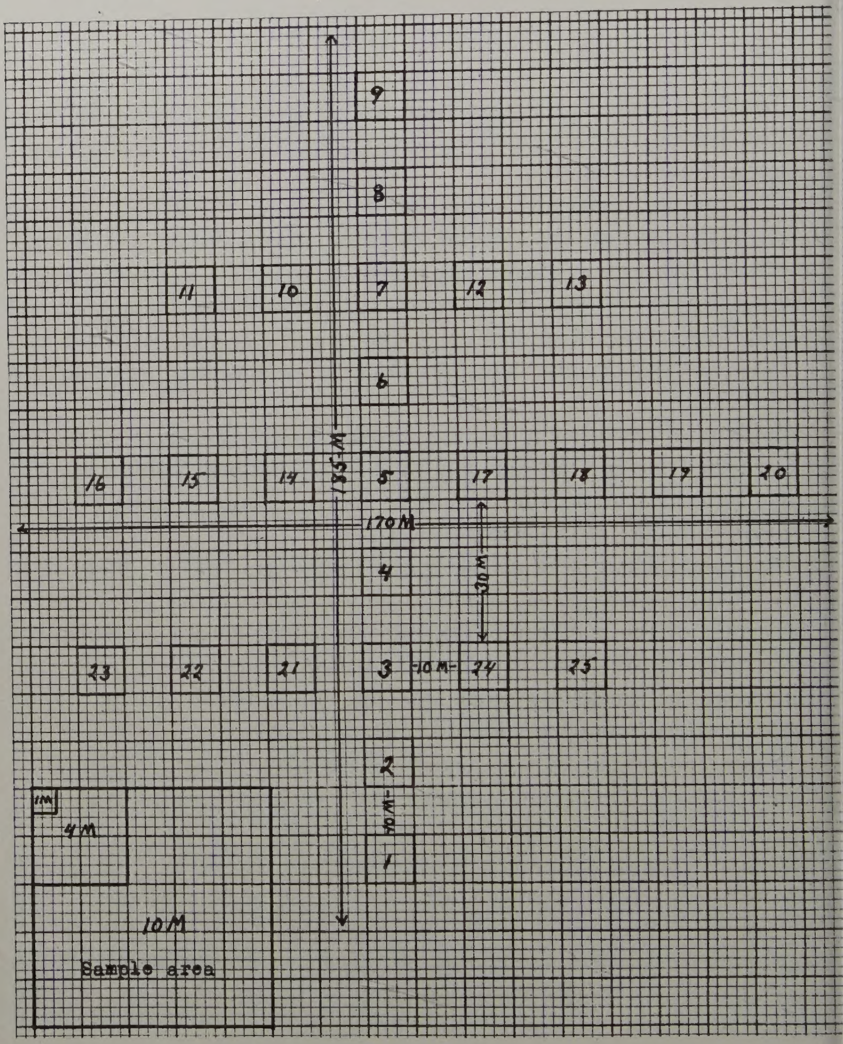
Interest in the vegetational composition of this bog was stimulated by the fact that it bears the only pure stand of *Pinus Strobus* in Indiana (1), and that it differs from the more common tamarack bog of the northern part of the state.

The approximate area of the bog is forty acres, and is divided into three distinct plant zones. *Pinus Strobus* occupies about nine acres in the center of the mat, completely surrounded by shrubs, of which the more common are *Rhus vernix, Rosa palustris* and *Spiræa tomentosa.* Encircling the shrubs is a sedge meadow. The adjacent untilled slopes are covered with an open and broken stand of oaks.

A quantitative survey was made in the white pine zone by the quadrat method (6). Twenty-five sample areas, each of three different sizes, were methodically arranged and equally spaced in accordance with Figure 1, so as to give a fair cross section of the flora. None of the quadrats touched the transition area next to the shrub zone where there were species intermingled characteristic of both areas. This precaution was taken to make the survey among the most homogeneous part of the vegetation. The species in each quadrat were located by symbols on sheets taken into the field (Figure 2). Quadrats, 1, 4 and 10 meters square, were used respectively for herbaceous species, shrubs and trees. Quadrats of these sizes permitted a 6 per cent. survey for trees, a 1 per cent. for shrubs, and 0.06 per cent. for herbaceous species.

From the sample sheets plotted in the field were compiled the fre-

FIGURE 1. ARRANGEMENT OF QUADRATS IN WHITE PINE ZONE



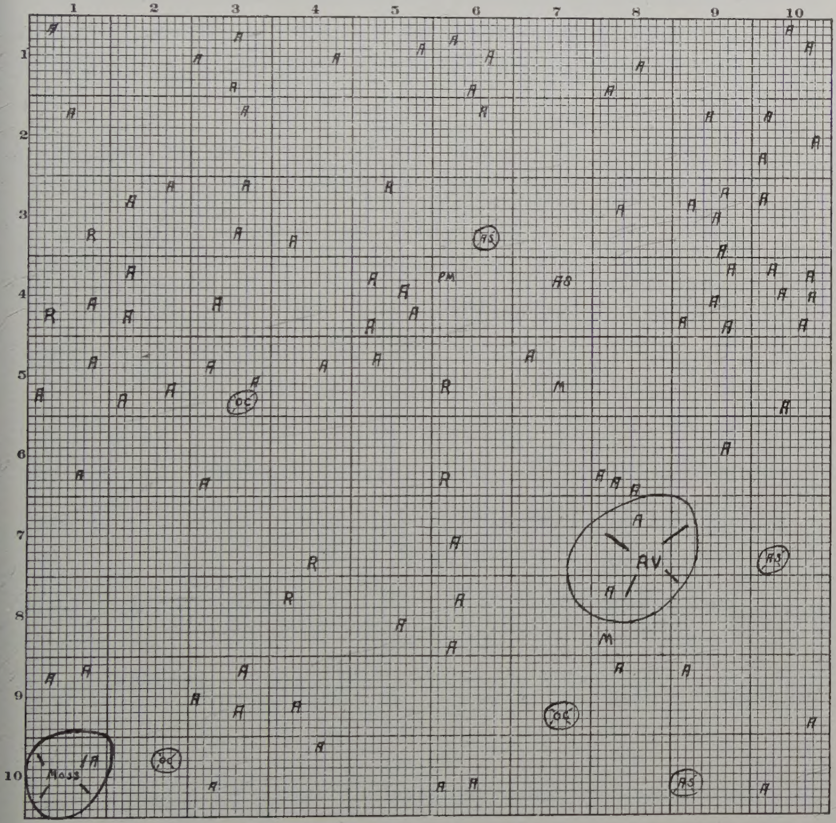
quency, frequency class and density of each species in accordance with these concepts as set forth by Braun-Blanquet and Pavillard (2), and recently interpreted by Cain (3). Frequency indicates the percentage of

FIGURE 2. SAMPLE OF FIELD SHEET

PROJECT Merrillville Bog

QUADRAT NO. 25-1Meter DATE 8-6-31

LOCATION MAPPED BY A.J.Lindsey



the total number of quadrats in which a species is found. A frequency class indicates the range of frequency of the species it contains. The frequency of each species falls into one or the other of five classes, designated as A, B, C, D and E, with the respective frequency ranges of 1-20, 21-40, 41-60, 61-80 and 81-100 per cent. Density, a strictly numerical concept, gives the average number of individuals of a species per quadrat.

The results of the survey in the twenty-five one-meter quadrats are given in Table I. A total of sixteen species was found, of which ten were herbaceous and sixteen were shrubs. The only tree species found was an oak seedling. The species of highest frequency were all herbs; and, with the exception of *Rubus hispidus,* had also the heaviest density. *Maianthemum canadense* had 96 per cent. frequence and was preponderately the most dense, but the ferns with a lower frequence and density were the more dominant because of their high surface coverage (Figure 4).

TABLE I. QUANTITATIVE COMPARISON OF SPECIES IN TWENTY-FIVE ONE-METER QUADRATS

SPECIES	FREQUENCY PER CENT.	FREQUENCY CLASS A	B	C	D	E	DENSITY
Aspidium cristatum L.	12	X					0.20
Aspidium spinulosum intermedium Muhl.	80				X		2.68
Eupatorium perfoliatum L.	4	X					0.04
Galium trifidum L.	4	X					0.04
Ilex verticillata L.	8	X					0.24
Lycopus sp.	12	X					0.72
Maianthemum canadense Desf.	96					X	90.24
Medeola virginiana L.	60			X			2.96
Osmunda cinnamomea L.	84					X	4.24
Pyrus melanocarpa (Michx.) Willd.	12	X					0.16
Quercus bicolor Willd.	4	X					0.04
Rhus vernix L.	56			X			0.76
Ribes americana Miller	4	X					0.04
Rubus hispidus L.	44			X			4.52
Vaccinium oxycoccus L.	4	X					0.04
Woodwardia virginica (L.) Sm.	16	X					0.36
Total (16)		10		3	1	2	

In the twenty-five four-meter quadrats (Table III) twelve woody species were found, of which nine were shrubs and the remainder trees. The species of the highest frequency and greatest density were the shrubs. By increasing the quadrats from 1 to 16 square meters, two trees came into the survey: *Pinus Strobus* and *Quercus macrocarpa. Quercus bicolor* and *Ribes americana* were found in the one-meter and four-meter quadrats but neither increased its frequency in changing from the smaller to the larger area. This condition may be accounted for by the fact that Quercus and Ribes are just coming in and are not distributed to any uniform extent. The established shrubs show an increase in frequency and density (Table IV) when data from larger quadrats are compared with that of smaller quadrats.

TABLE III. QUANTITATIVE COMPARISON OF SPECIES IN TWENTY-FIVE FOUR-METER QUADRATS

SPECIES	FREQUENCY PER CENT.	FREQUENCY CLASS A	B	C	D	E	DENSITY
Ampelopsis quinquefolia Michx.	36		X				0.68
Corylus americana Walt.	8	X					0.08
Ilex verticillata L.	52			X			0.88
Pinus Strobus L.	24		X				0.36
Pyrus melanocarpa (Michx.) Willd.	32		X				1.12
Quercus bicolor Willd.	4	X					0.04
Quercus macrocarpa Willd.	12	X					0.16
Rhus vernix L.	100					X	4.60
Ribes americana Miller	4	X					0.04
Rubus hispidus L.	88					X	?
Sambucus canadensis L.	4	X					0.04
Sorbus subvestita Greene	4	X					0.04
Total (12)		6	3	1		2	

TABLE IV. SPECIES SHOWING INCREASE IN FREQUENCY AND DENSITY IN CHANGING FROM SMALLER TO LARGER QUADRATS

SPECIES	ONE-METER QUADRATS FREQUENCY PER CENT.	DENSITY	FOUR-METER QUADRATS FREQUENCY PER CENT.	DENSITY
Ilex verticillata	8	.24	52	.88
Pyrus melanocarpa	12	.16	32	1.12
Rhus vernix	56	.76	100	4.60
Rubus hispidus	44	4.52	88	?
Pinus Strobus			24	.36

The increase in frequency and density in passing from the one-meter to the four-meter quadrats shows that the one-meter quadrats are too small for a shrub survey, and likewise the four-meter quadrats for trees. A quadrat that will not normally include all the more important species and some of the less important ones is too small for an adequate survey (6). *Nemopanthus mucronata,* a rather common shrub, appeared quite often just outside of the four-meter quadrats. It was a shrub too common not to have figured in a statistical survey. It might be said in this connection that even four-meter quadrats are too small for certain types of vegetation.

The increase in frequency of an area over that of a smaller one also raises a question regarding the relation between the number of species and quadrat size. Arrhenius attempted to show that the number of species will increase continually as the area increases and produced a formula to give the mathematical relationship (7). Gleason has exposed the fallacy of such a correlation by showing that it increases species to an incredible ratio. Gleason does admit a more or less logarithmic relationship between species and quadrat size up to the point where the quadrat is not extended beyond a size sufficient to include all species represented in a community. He has also shown that the rate of increase in the number of species is a progressive decrease toward the enlarged areas (7). The findings in this study are more in agreement with Gleason as against the formula of Arrhenius.

Table V shows that only four species of trees appeared in the twenty-five ten-meter quadrats. This is an increase of one species, *viz., Prunus serotina,* over the four-meter quadrats. *Quercus bicolor* and *Q. macrocarpa* show a very slight increase in frequency and density in passing from the four-meter to the ten-meter series. Again, it may be stated that the oaks are seedlings in the beginning of their succession and have no uniformity in their distribution. *Pinus Strobus,* with 24 per cent. frequency in the four-meter quadrats, jumps to 100 per cent. in the ten-meter quadrats. *Pinus Strobus* is the important tree at present, but it is doomed to yield its position to the incoming oaks. A pine seedling is rarely found on the forest floor, while oak seedlings are more common, thus indicating that the pines are yielding to an oak succession. And in addition to this apparent unsuccessful competition with the oaks, the pines do not display a vigorous vegetative condition, another indication of a passing species. In their present condition they are an illustration of a species unable to withstand a changing bog habitat (5).

TABLE V. QUANTITATIVE COMPARISON OF SPECIES IN TWENTY-FIVE TEN-METER QUADRATS

SPECIES	FREQUENCY PER CENT.	FREQUENCY CLASS A	B	C	D	E	DENSITY
Pinus Strobus L.	100					X	2.36
Prunus serotina Ehrh.	8	X					.08
Quercus bicolor Willd.	8	X					.08
Quercus macrocarpa Willd.	16	X					.36
Total (4)		3				1	

There seems to be no correlation between frequency and density in any quadrat study to the extent that a species of the highest frequency will always have the greatest density and that a species of lowest density will always have the lowest frequency. It happens in this survey, however, that the species of the highest frequence have also the greatest density. This numerical relationship does not hold good for all species in Tables I and III, for some of low density have a greater frequence than some whose density is much higher. While there is no hard and fast correlation between frequency and the density of individuals as a species, yet there is a rather definite logarithmic relationship between the two. Knowing the number of quadrats and the number of plants of an individual species found in the quadrats, it is possible to approximate the frequency per cent., and conversely, knowing the number of quadrats and frequency per cent., it is possible to approximate the number of individuals of a species appearing in the quadrats. Especially is this relation true among the species of low frequency. For a discussion of the formula used in establishing this relationship, reference should be made to Gleason (7) and Kenoyer (8).

The frequency curves in Figure 3 show the percentage of species in each of the frequency classes for the three quadrat series in comparison with the curve of Raunkiaer, which was based on the result of European surveys, and the curve of Kenoyer based on quadrat studies in Michigan. The present results are in agreement with Raunkiaer's curves in the four-meter and ten-meter quadrats in that there are two peaks, one in A and the other in E, but the four-meter quadrats show a total depression in D, and the ten-meter quadrats a total depression in B, C and D. The total depressions are not in agreement with Raunkiaer's gradual decrease through the intermediate classes. The curve of the one-meter group exhibits more of a departure from Raunkiaer's curve in that there are three peaks, one each in A, C and E, with a total depression in B.

The composition of the white pine and its contemporary flora present a very distinct stratification. Five different layer societies are thus composed. Mosses and *Maianthemum canadense* compose the lowest stratum, *i. e.*, up to 8 inches. This is followed by other strata in the following order: Osmunda and Aspidium, 8 inches to 4 feet; Ilex, Pyrus and Nemopanthus, 4-10 feet; *Rhus vernix*, 10-18 feet; and *Pinus Strobus*, 18-50 feet. The clean-cut way in which these layers are superimposed one upon another made it possible to estimate their dominance with

FIGURE 3. CURVES SHOWING THE PER CENT. OF SPECIES IN EACH OF THE DIFFERENT FREQUENCY CLASSES OF THE THREE DIFFERENT QUADRAT GROUPS IN COMPARISON WITH RAUNKIAER'S AND KENOYER'S STANDARD CURVES

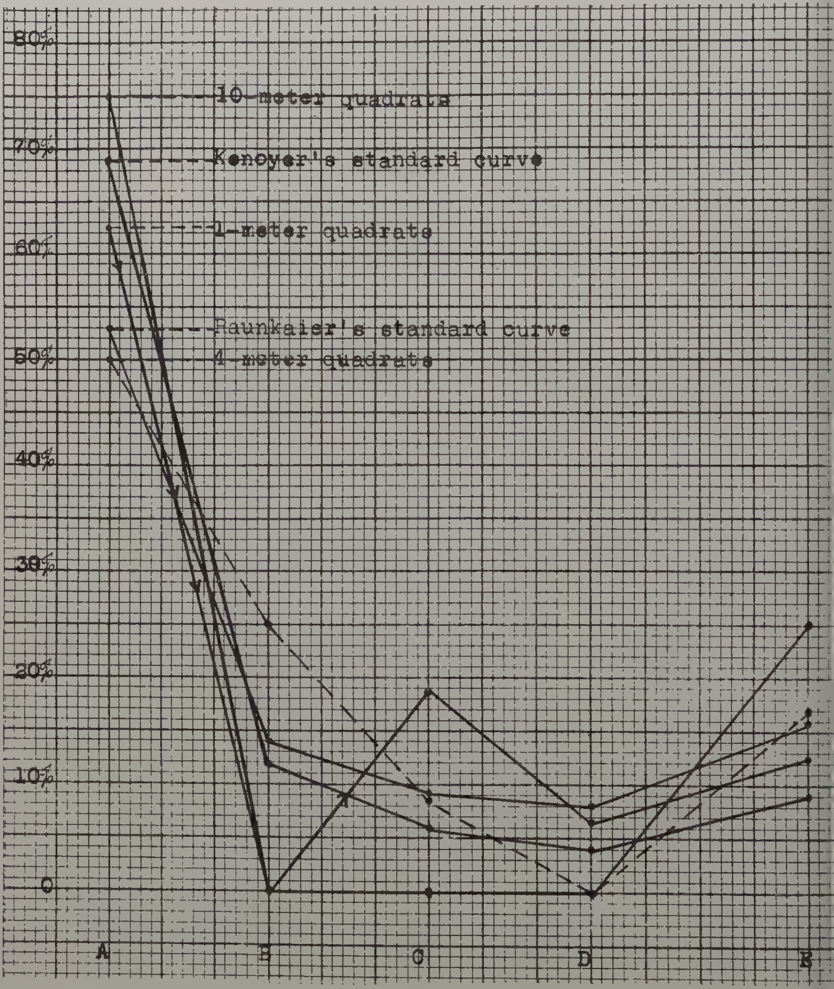
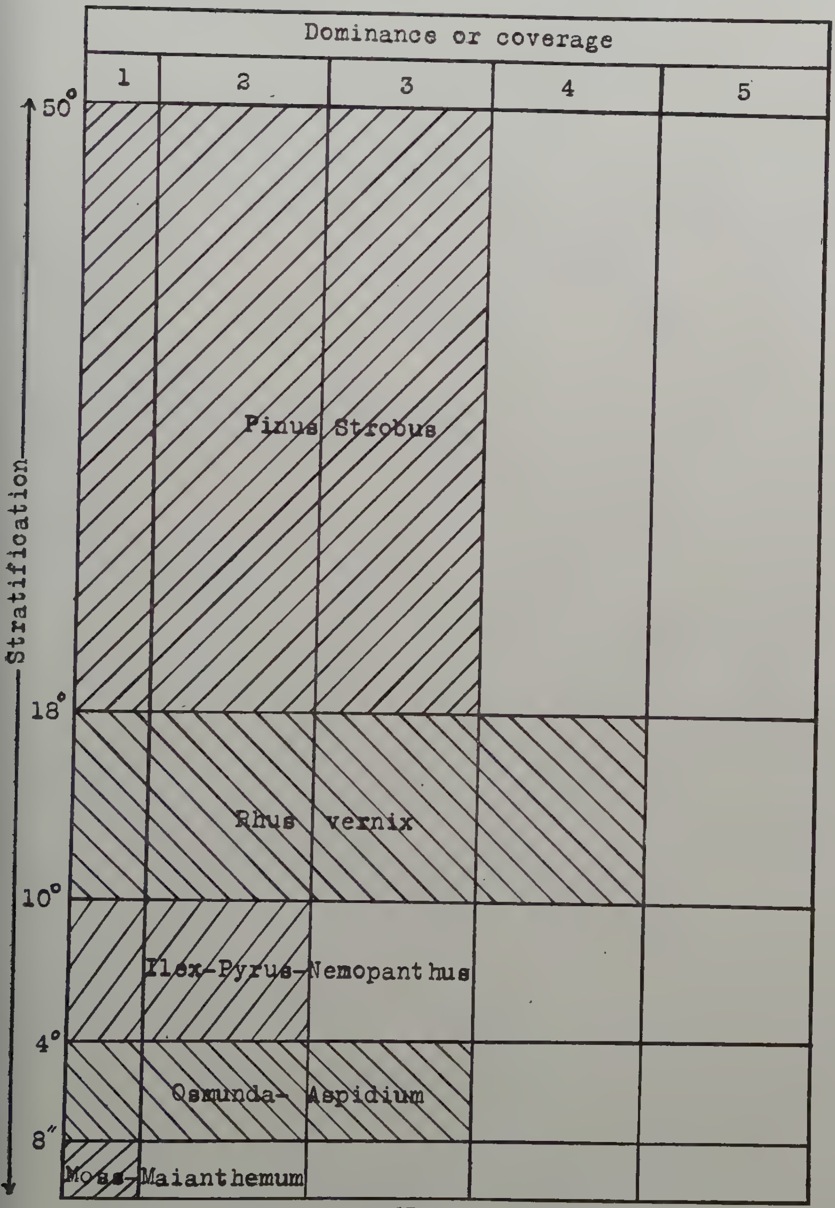


FIGURE 4. STRATIFICATION AND DOMINANCE OF SPECIES FORMING THE DIFFERENT STRATA



comparative ease. Dominance as here used refers to coverage and is divided into five classes: D-1, less than 1/20 of area; D-2, 1/20-¼; D-3, ¼-½; D-4, ½-¾; and D-5, more than ¾ of the area (2). Figure 4 shows the different vegetational strata in relation to their height and gives the dominance of each species or group of species forming a particular stratum. Special notice should be given *Pinus Strobus*, with a D-3 coverage, which shows it to be very open for a dominant tree in a pure stand. The shrubs are unusually dense, with reference to *Rhus vernix* in particular. The ferns also have more than ordinary dominance. The idea of the coverage-stratification diagram used in Figure 4 was advanced by Cain (3).

TABLE IV. LIST OF SPECIES FOUND OUTSIDE OF QUADRATS

Agrimonia sp.
Aralia nudicaulis L.
Aspidium Thelypteris (L.) Sw.
Carex impressa?
Carex sp.
Calamagrostis canadensis (Michx.) Beauv.
Gaylussacia baccata (Wang.) C. Koch.
Geum sp.
Lysimachia sp.
Nemopanthus mucronata (L.) Trel.
Osmunda regalis L.
Polygonum sagittatum L.
Prunus americana Marsh.
Quercus imbricaria Michx.
Rosa palustris Marsh.
Sagittaria sp.
Scirpus cyperinus (L.) Kunth.
Solanum Dulcamara L.
Spiræa tomentosa L.
Circium sp.
Vaccinium vaccillans Kalm.
Vitis sp.

Total, 22

SUMMARY AND CONCLUSIONS

1. The species of highest frequency in each quadrat series also have the greatest density.

2. In general, the species of the highest frequency and greatest density are dominant in the stratum in which they are found.

3. One-meter quadrats seem sufficient in size for making an adequate survey of herbaceous species, and the ten-meter quadrats for trees, but four-meter quadrats seem undersized for a fair survey of shrubs.

4. *Pinus Strobus* has neither great density nor coverage for being a dominant tree in a pure stand.

5. In this study *Pinus Strobus* is the dominant tree, *Rhus vernix* the dominant shrub, *Maianthemum canadense* the dominant herb on the forest floor, and *Osmunda cinnamomea* and *Aspidium spinulosum intermedium* share dominance among the taller herbs.

6. Raunkiaer's law of frequence is not completely supported by the frequency curves of the different quadrat series.

7. *Vaccinium oxycoccus* is almost extinct and *Ampelopsis quinquefolia* is rather common in seedling form, thus indicating the increasing dryness of the bog.

8. The shrubs and ferns exhibit unusually heavy stands.

9. The Merrillville bog has not yet reached its climax stage. This fact is attested by the almost total lack of pine seedlings but with oak seedlings much more abundant.

Appreciation is here extended to Miss Dorothy Parker, who assisted in laying out the quadrats and mapping some of the areas, and to Dr. Stanley A. Cain for suggesting and supervising this study.

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PRELIMINARY FOSSIL POLLEN ANALYSIS OF THE MERRILLVILE, INDIANA, WHITE PINE BOG

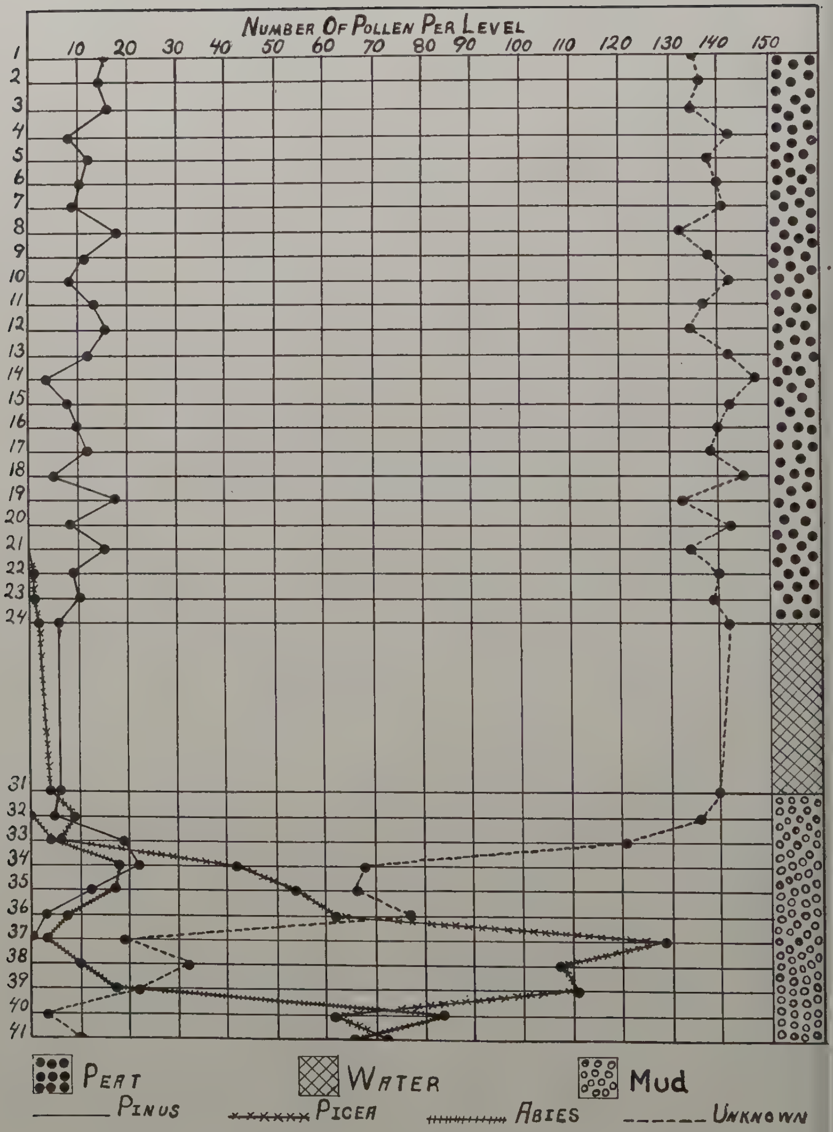
By ALVA J. LINDSEY

This analytical study in fossil pollen is not as complete as present methods and knowledge of pollen will permit. Pending a more extensive analysis, a few preliminary findings are here set forth, but, of course, subject to future modification.

Soundings were made in the Merrillville bog (2) at different points to ascertain the deepest place. Depths ranged between twenty-three and forty-one feet. At depths of twenty-three and twenty-four feet the bog mat rested on the hard blue mud bottom of the old lake bed. No peat was found to exceed twenty-four feet, but where the depth was greater the bog mat rested on seven feet of water and ten feet of mud. It was impossible to secure a peat sample between the twenty-fourth and thirty-second foot levels. Numerous trials were made but with negative results. The conclusion was reached that water underlies the bog mat and that the mat is still floating at the point where the samples were taken.

Samples of peat were taken at each foot level between one and twenty-four feet, while samples of mud were taken at each foot level between thirty-two and forty-one feet. As a safeguard against contamination, the portion retained for laboratory use was removed from the center of the two-inch core. Each sample was immediately bottled and tightly stoppered. Before each descent of the auger, the cylinder was thoroughly washed, especially on the inside, to remove the residue of the previous core. An additional precaution against contamination was the gathering of samples in the month of December, when the surface of the bog mat was frozen and the air was not laden with migrating pollen. The taking of samples during a period of freezing also eliminates the disagreeable feature of wading water and muck.

All samples were taken to the laboratory for immediate examination. A small portion of each sample was boiled in a 10 per cent. KOH solution with a trace of safranin added for staining. The stained grains are more readily discernable under the microscope. After boiling, the peat was centrifuged, decanted, rinsed in distilled water, centrifuged and decanted again. The boiling in KOH solution and centrifuging is unquestionably severe treatment, for it ruins the structure of many grains,


NUMBER OF POLLEN PER LEVEL
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
31
32
33
34
35
36
37
38
39
40
41
PEAT
WATER
Mud
PINUS
PICEA
ABIES
UNKNOWN

but the tenacity with which colloidal peat clings to the pollen is broken only by some such treatment. Deflocculation was an utter failure when the peat was bathed in water only; and but little more satisfactory when boiled in distilled water and centrifuged. The pollen grains were more readily separated from the mud than from the peat, boiling in distilled water and centrifuging being adequate for deflocculation. Permanent slides were made by removing a bit of the top precipitate from the centrifuge tube with a pipette and mounting it in glycerine jelly. The cover glass was then ringed with balsam. Identification was on the basis of measurements made of extant pollen grains of identical genera as well as comparison with Sears' (3) drawings and descriptive key.

The early workers in fossil pollen (1, 3) claim that trustworthy results are obtainable by counting one hundred or one hundred and fifty grains per level. The latter number was used in this study. Differentiation was made between winged coniferous and unknown genera. The winged coniferous pollen was further differentiated as to the genera: Abies, Picea and Pinus.

The diagram shows the analysis graph and bog profile. The bog consists of three main strata: peat, water and mud. Further stratification has not been undertaken. The three main strata are shown by respective markings at the right of the diagram. The numbers at the left represent the different levels at intervals of one foot each. The numbers horizontally placed at the top indicate the relative number of grains found on each level.

Pollens of Abies and Picea have their maximum accumulation in the mud stratum. Both appear in the lowest level. Abies is confined to the mud stratum, disappearing at the thirty-second foot level. Picea extends into the peat, disappearing at the twenty-second foot level. It seems that pollens of Abies and Picea were deposited in large degree during the open-water stage of the lake before the bog mat was formed. It was striking to note the almost pure stand of Abies and Picea and the dearth of vegetable matter in the lower mud levels. Picea was the more abundant of the two genera. Pinus appears in the mud at the thirty-sixth foot level and continues unbroken to the surface. It makes its appearance with a noticeable increase in unknown genera. An analytical study of the vegetation (2) has shown that *Pinus Strobus* now inhabits the surface of the bog mat in pure stand. The order of post-glacial succession has been Abies-Picea, Picea-Pinus and Pinus-other genera.

SUMMARY AND CONCLUSIONS

1. The Merrillville bog consists of three general strata: peat, water and mud. The mat is still floating at the point where samples were taken.

2. Pollens of Abies and Picea reach their maximum accumulation in the mud stratum, indicating their deposition during the open-water stage of the lake.

3. The pollen present in the mud stratum is almost entirely that of Abies and Picea.

4. The appearance of Pinus pollen is accompanied by pollen from many other genera.

5. The order of the postglacial succession in this bog area has been Abies-Picea, Picea-Pinus and Pinus-other genera.

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A STATISTICAL STUDY OF A BEECH-MAPLE ASSOCIATION AT TURKEY RUN STATE PARK, PARKE COUNTY, INDIANA

By MABEL M. ESTEN

INTRODUCTION

In 1928 Braun-Blanquet and Pavillard (1) published the "Vocabulaire de Sociologie Végétale," in which an attempt was made to define and standardize the various current concepts relating to descriptive phytosociology. Since the continental concepts vary somewhat from those of American workers, the terminology differs slightly. The terms relating to the organization of any plant community are, according to them, arranged in a sociological "Relève" or floristic enumeration in which each species of plant is given with the coefficient or number corresponding to the class to which it belongs in the analytical or synthetic concepts. Cain (2) has arranged these concepts into a tabular form which is convenient for use in a statistical study of any plant community. Up to the present, no field study of any American plant community has been made which uses all the concepts embodied in Cain's summary, although several studies have considered a few of them. In the present study of a beech-maple association, the analytical concepts of density, dominance, frequence, sociability, vitality, periodicity and stratification, and the synecological concepts of life-form and leaf-size classes were considered. Since a complete explanation of these concepts is given in Braun-Blanquet and Pavillard's work (1) and also in Cain's study (2), they will be explained only in brief form here.

EXPLANATION OF CONCEPTS

The concept of *density* concerns the number of individuals per unit area, that is, the abundance divided by the area.

Dominance or coverage is concerned with the space occupied by individuals of each species. In this study foliage or crown coverage is considered. The scale of dominance is expressed in five classes as follows:

Class 1—Covering 1-5 per cent. of the area.

Class 2—Covering 6-25 per cent. of the area.

Class 3—Covering 26-50 per cent. of the area.

Class 4—Covering 51-75 per cent. of the area.

Class 5—Covering 76-100 per cent. of the area.

Frequence is an expression in per cent. indicating the relation the quadrats in which a species is found bear to the total number of quadrats examined. There are five classes of frequency listed alphabetically as follows:

Class A (1)—Species found in 1-20 per cent. of quadrats.

Class B (2)—Species found in 21-40 per cent. of quadrats.

Class C (3)—Species found in 41-60 per cent. of quadrats.

Class D (4)—Species found in 61-80 per cent. of quadrats.

Class E (5)—Species found in 81-100 per cent. of quadrats.

Sociability concerns the manner in which individuals of one species occur in relation to each other and to individuals of other species. It is divided into five classes:

Class 1—Species in isolation.

Class 2—Species in groups.

Class 3—Species in numbers.

Class 4—Species in small colonies.

Class 5—Species in large colonies.

Vitality concerns the degree of vigor and prosperity of the species, that is, the degree of consummation of all normal functions of growth and reproduction. There are three vitality classes:

Class 1—Species of low vitality, stunted vegetative form and having little or no fruit.

Class 2—Species with good vegetative form but having an incomplete life cycle.

Class 3—Species performing all normal functions.

The *periodicity* of plants is determined in this study by the season during which they flower. The four classes of periodicity, corresponding to the calendar seasons, are as follows:

Class 1—Spring or vernal.

Class 2—Summer or estival.

Class 3—Autumn or autumnal.

Class 4—Winter or hibernal.

Stratification or layering classes are the divisions of the plant community into horizontal layers, superimposed on each other. In this study the strata were considered as follows:

Class 1—Tall trees, above thirty-five feet in height.
Class 2—Short trees, below thirty-five feet in height.
Class 3—Woody shrubs and vines.
Class 4—Herbs (all sizes).

Life-forms are determined according to Raunkiaer's (see Smith, 7) classification of plants on the basis of the location of the perennating bud. There are ten classes, six of which are found in the present study:

Therophytes (Th.)—Annuals living over in the form of seeds.

Geophytes (G.)—Plants with vegetative organs, bulbs, tubers, rhizomes or similar structures, below the surface of the soil. Geophytes are one of the three divisions of the Cryptophytes: Hydrophytes and Helophytes being absent here.

Hemicryptophytes (H.)—Herbaceous plants with the dormant buds just below the surface of the soil.

Chamæphytes (Ch.)—Creeping or rosette plants with the perennating buds on the ground or not more than 25 cm. above it.

Phanerophytes—Woody plants with dormant buds more than 25 cm. above the soil surface. These plants are classified according to height as Nanophanerophytes (N.), from 25 cm. to 2 meters high; Microphanerophytes (M.), 2-8 meters; Mesophanerophytes (Ms.), 8-30 meters; and Megaphanerophytes (Mg.), over 30 meters high.

Leaf-sizes are based on Raunkiaer's (see Smith, 7) classification according to size of typical leaves. The classes follow:

1. Leptophyll (Lepto.), 25 sq. mm. or less in surface.
2. Nanophyll (Nano.), 25 sq. mm.-225 sq. mm.
3. Microphyll (Micro.), 225 sq. mm.-2,025 sq. mm.
4. Mesophyll (Meso.), 2,025 sq. mm.-18,225 sq. mm.
5. Macrophyll (Macro.), 18,225 sq. mm.-164,025 sq. mm.
6. Megaphyll (Mega.), larger than macrophyll.

LOCALITY AND METHOD

Indiana contains a few tracts of virgin timber and others which are practically so, that is, little selective cutting and no grazing have taken place. Since they are few and are rapidly decreasing, it is necessary that studies be made of them soon in order that contributions to their vegetational history be preserved. A virgin beech-maple association *(Fagus grandifolia-Acer saccharum)* at Turkey Run State Park, Parke county, Indiana, was selected as the site of a statistical study according to the ecological concepts outlined above. The tract under consideration is approximately four and one-half acres in size and is bounded on all sides by deep ravines. On the east and north the sandstone canyons are about 60-70 feet in depth. Along a very narrow strip of sloping land next to the rim of these canyons and on the upper limits of them is a practically pure stand of *Tsuga canadensis,* a relict association which has been studied by Daubenmire (3). The beech-maple climax comes to the edge of the hemlocks. On the west and south sides of the plateau the ravines are less deep and the sandstone has been covered by soil, so the association comes to the rim of the ravines. In the entire area covered by the beech-maple association, a small amount of cutting has been done, but this is so slight that it was considered of little importance in the results to be gained from the study.

Twenty-five one-meter square, twenty-five four-meter square, and twenty-five ten-meter square quadrats were regularly and widely distributed and permanently marked throughout the area covered by the beech-maple association. These were so arranged that the one-square-meter quadrats were enclosed in the sixteen-square-meter and the sixteen-square-meter within the 100-square-meter quadrats.

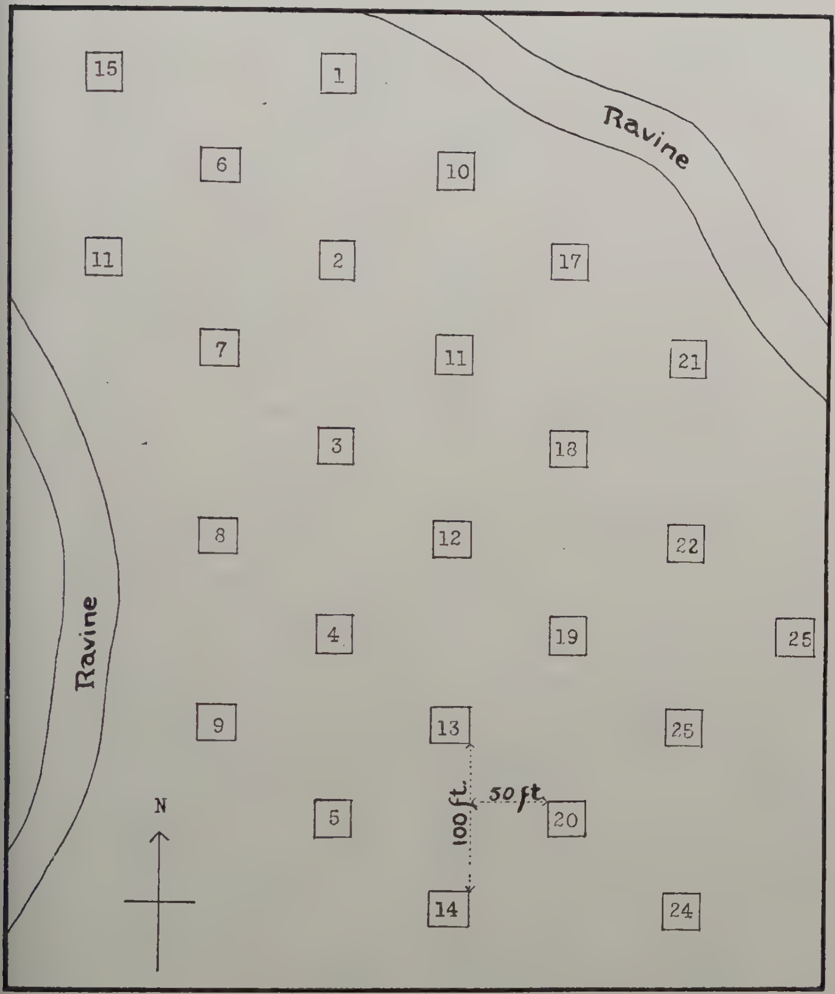
The quadrats were distributed as evenly as possible over the entire area covered by the beech-maple association as shown in Figure 1.

Woody plants above two inches in diameter four and one-half feet above the ground (diameter breast high, DBH) were studied in the ten-meter quadrats, woody plants below two inches (DBH) in the four-meter quadrats and herbaceous plants in the one-meter quadrats. In order that as complete a study as possible might be made during the growing season, the work was begun early in April and continued until late in November. At intervals of approximately two weeks during the period of study all the quadrats were observed and additions made to the total floristic list for the quadrats. Also, a complete floristic list for the entire area was made.

Since the twenty-five one-meter quadrats covered only approximately 0.1 per cent. of the total area and the total of thirty-two herbaceous plants in the quadrats was 43 per cent. of the total number of herbaceous plants in the entire area, it is seen that in this case the sampling or quadrat method, although of small area, gives a fairly accurate analysis, at least of the most characteristic species of the vegetation.

The four-meter quadrats covered approximately 1.6 per cent. of the

FIGURE 1. DISTRIBUTION OF QUADRATS IN AREA



area. The twenty-six species of woody plants below two inches (DBH) which are found in them are 70 per cent. of the total number of species of woody plants in the entire area. However, in the total list no attempt was made to differentiate size classes so there can be no indication of the efficiency of the method. The same is true of the ten-meter quadrats,

TABLE I. SOCIOLOGICAL SUMMARY OF SPECIES OCCURRING IN ONE-METER QUADRATS

FLORISTIC LIST	CONCEPTS RELATING TO SPECIES COMPOSING A PLANT COMMUNITY								
	I ORGANIZATION							II SYN-ECOLOGY	
	ANALYTIC								
	Quantitative			Qualitative					
SPECIES	a. DENSITY	b. DOMINANCE (Classes 1-5)	c. FREQUENCE (Classes 1-5, A-E)	a. SOCIABILITY (Classes 1-5)	b. VITALITY (Classes 1-3)	c. PERIODICITY (Classes 1-4)	d. STRATIFICATION (Classes 1-5)	a. LIFE FORM (Classes 1-10)	b. LEAF SIZE (Classes 1-6)
Actæa alba	.04	1	A	2	3	1	4	G.	Micro.
Adiantum pedatum	.24	1	A	2	3	2	4	H.	Nano.
Arisæma triphyllum	1.12	1	B	2	3	1	4	G.	Meso.
Aspidium marginale	.04	1	A	2	3	2	4	H.	Micro.
A. marginale elegans	.08	1	A	2	3	2	4	H.	Micro.
Asplenium angustifolium	.04	1	A	2	3	2	4	H.	Micro.
Brachyelytrum erectum	.84	1	A	2	3	2	4	H.	Micro.
Carex (Sp?)	.04	1	A	2	3	2	4	H.	Meso.
Circaea lutetiana	1.12	1	A	2	3	2	4	H.	Meso.
Claytonia virginica	4.16	1	C	4	3	1	4	G.	Micro.
Cystopteris fragilis	.04	1	A	2	3	2	4	H.	Nano.
Dentaria laciniata	7.24	1	C	2	3	1	4	G.	Micro.
Desmodium nudiflorum	.04	1	A	2	3	2	4	G.	Micro.
Dicentra canadensis	70.72	2	D	4	3	1	4	G.	Micro.
Epifagus virginiana	.88	1	A	4	3	2	4	G.	Leafless
Erythronium americanum	33.24	1	E	4	3	1	4	G.	Micro.
Galium aparine	.48	1	A	4	3	1,2	4	Th.	Nano.
G. circæzans	.40	1	A	2	3	1,2	4	H.	Micro.
G. concinnum	4.32	1	A	4	3	1,2	4	H.	Lepto.
Geum canadensis	.04	1	A	2	3	1,2	4	H.	Micro.
Hydrophyllum appendiculatum	.12	1	A	2	3	1	4	H.	Meso.
H. macrophyllum	.04	1	A	2	3	1	4	H.	Meso.
Impatiens pallida	.12	1	A	4	3	2	4	Th.	Meso.
Lappula virginiana	.08	1	A	3	3	2	4	Th.	Meso.
Oxalis violacea	.04	1	A	2	3	1	4	G.	Micro.
Phytolacca decandra	.48	1	A	2	3	2	4	G.	Meso.
Pilea pumila	.08	1	A	2	3	2	4	Th.	Macro.
Podophyllum peltatum	2.84	1	B	2	2	1	4	G.	Meso.
Polygonum scandens	.04	1	A	2	3	2	4	H.	Meso.
Smilacina racemosa	.44	1	A	2	3	1	4	G.	Meso.
Trillium recurvatum	.04	1	A	2	3	1	4	G.	Meso.
Viola papilionacea	.16	1	A	2	3	1	4	H.	Meso.

which covered about 10 per cent. of the area. The twelve species above two inches (DBH) in the quadrats are approximately 32 per cent. of the total number of woody species.

SUMMARY AND DISCUSSION OF RESULTS IN THE ONE-METER QUADRATS

Table I gives the complete statistical summary for herbaceous species found in the one-meter quadrats.

The concept of *density* concerns the number of individuals per unit area, and the numerical value is gained by dividing the total number of individuals by the total number of one-meter quadrats. Density may thus be defined here as the average number of individuals of a species in a quadrat. From the previous table, it will be observed that *Dicentra canadensis* has the highest density, 70.72, and *Erythronium americanum* is second highest with a density of 33.24. The total density of all species is 129.60 plants per square meter.

None of the species found in the one-meter quadrats covered more than 5 per cent. of the area of the quadrats, except *Dicentra canadensis,* which covered from 6 to 25 per cent. of the area. This low dominance is no doubt due to the fact that all the plants considered in the one-meter quadrats were herbaceous and were small, early flowering types.

Eighty-two per cent. of the species were in Class A of frequency; that is, they appeared in only from 1.0 to 20 per cent. of the quadrats. Six per cent. were in Class B and the same in Class C. Three per cent. were in Class D and 3 per cent. in Class E. *Erythronium americanum* was the only species appearing in Class E, the class of highest frequence, and it occurred in 88 per cent. of the quadrats. A comparison of these frequency percentages with those of Raunkiaer and Kenoyer will be given later with the comparisons of the percentages of the four- and ten-meter quadrats.

Sociability concerns the manner in which species occur in relation to others, and the classes given in the summary were estimated on the basis of the numbers of individuals of all species growing in the quadrats. It will be noted that 75 per cent. of all the species appeared in Class 2; that is, they appeared in small groups. No species were found in isolation nor in Class 5, although seven species were in Class 4 and one in Class 3.

All plants except *Podophyllum peltatum* exhibited a vitality of 3, performing all normal functions of vegetative growth and reproduction. Due to some undetermined cause, practically none of the plants of *Podophyllum peltatum* produced flowers and fruit, although they had a normal vegetative growth and were consequently in Class 2.

The classes of periodicity were determined on the basis of the calendar seasons during which the plants bloomed. A few species continued blooming during two seasons, but the majority of species produced flowers only in one season. Forty-one per cent. of the species were found to be spring flowering and 47 per cent. summer flowering. These percentages support the generally accepted observation of the vernal and estival aspect of the herbaceous plants found in beech-maple associations. Twelve per cent. of the species flowered during two seasons. These were *Geum canadensis* and the three species of *Galium*.

No attempt was made to indicate subdivisions in the strata of species in the quadrats, and they were grouped only in the four large classes indicated previously. Since only herbaceous plants were studied in the small quadrats, all species were in Class 4. Only Pteridophytes and Spermatophytes were considered, and consequently a possible fifth stratum, a moss-lichen or carpet layer, was omitted. It was very poorly developed in this association.

Raunkiaer's classification of plants on the basis of the location of the perennating bud was used to determine the life-forms of the species present. The complete description of the ten life-form classes and the normal spectrum is given by Smith (7) and Fuller and Bakke (5). Withrow (8) has made use of the spectrum in a study of some plant communities of the Cincinnati region, but has subdivided the phanerophytes into different height classes from those of Raunkiaer. As a result, her work is not comparable with Raunkiaer's or any similar study unless all the phanerophytes are considered together without subdivision into the height classes. They have been so considered in making the following comparison of her results in a climax mixed mesophytic forest of the Cincinnati region with Raunkiaer's normal spectrum and the spectrum of all species found in the entire area of the beech-maple association of the present study.

LIFE FORM CLASSES	WITHROW Climax Mixed Mesophytic Forest		PRESENT STUDY Total Flora		RAUNKIAER Normal Spectrum	
	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.
Phanerophyte	43	33.58	38	32		47
Chamæphyte	5	3.88	3	3		9
Hemicryptophyte	44	34.4	45	39		27
Cryptophyte-Geophyte	30	23.4	24	21		3
Therophyte	5	3.9	6	5		13
Succulent	1	.78				
Totals	128	99.94	116	100	400	99

The predominance of hemicryptophytic life forms in the climax mixed mesophytic forest studied by Withrow and in the beech-maple association of the present study is in direct agreement with the findings of Raunkiaer (see Smith, 7, and Fuller and Bakke, 5) and Ennis (4). Phanerophytes are next important in dominance. The vegetation considered in the present study showed the direct connection with the climate of moderate temperature and rainfall which was apparent in the previous studies of similar associations.

In the twenty-five one-meter quadrats the herbaceous plants considered were in three life forms: Geophyte, 41 per cent., Hemicryptophyte, 47 per cent., and Therophyte, 12 per cent.

Raunkiaer's leaf size classes were used with the following tabulation of results:

LEAF SIZE	NO. HERBACEOUS SPECIES	PER CENT.
Leptophyll	1	3
Nanophyll	3	9
Microphyll	13	41
Mesophyll	13	41
Macrophyll	1	3
Aphyllous	1	3

The above tabulation shows clearly the dominance of the microphyll and mesophyll sizes over the other sizes, that is, the majority of the leaves were between 225 sq. mm. and 18,225 sq. mm. in surface area. In the case of compound leaves, one leaflet was considered the unit for measurement. The scale drawings of Fuller and Bakke (5) were used in determining the leaf sizes.

The following herbaceous species were found in the area but did not appear in any of the quadrats where herbaceous plants were considered: *Anemonella thalictroides, Arabis lævigata, Asarum canadense, Aspidium*

TABLE II. SOCIOLOGICAL SUMMARY OF SPECIES OCCURRING IN FOUR-METER QUADRATS

CONCEPTS RELATING TO SPECIES COMPOSING A PLANT COMMUNITY

FLORISTIC LIST OF WOODY PLANTS LESS THAN TWO INCHES IN DIAMETER	I ORGANIZATION							II SYN-ECOLOGY	
	ANALYTIC								
	Quantitative			Qualitative					
SPECIES	a. DENSITY	b. DOMINANCE (Classes 1-5)	c. FREQUENCE (Classes 1-5, A-E)	a. SOCIABILITY (Classes 1-5)	b. VITALITY (Classes 1-3)	c. PERIODICITY (Classes 1-4)	d. STRATIFICATION (Classes 1-5)	a. LIFE FORM (Classes 1-10)	b. LEAF SIZE (Classes 1-6)
Acer saccharum	15.96	2	E	3	3	1	1	Ms.	Meso.
Asimina tribola	.52	1	A	2	3	1	2	M.	Meso.
Carpinus caroliniana	1.12	1	B	2	3	1	2	Ms.	Meso.
Carya cordiformis	.32	1	B	2	3	1	1	Ms.	Meso.
Cornus florida	.92	1	A	2	3	1	2	M.	Meso.
Dirca palustris	2.24	1	C	3	3	1	3	N.	Meso.
Evonymus obovatus	17.76	1	A	3	3	2	3	Ch.	Micro.
Fagus grandifolia	1.12	1	C	2	3	1	1	Mg.	Meso.
Fraxinus lanceolata	2.52	1	C	2	3	1	1	Ms.	Meso.
Juglans nigra	.08	1	A	2	3	1	1	Mg.	Meso.
Liriodendron tulipifera	.20	1	A	2	3	1	1	Mg.	Meso.
Menispermum canadense	.08	1	A	2	3	2	3	N.	Meso.
Morus rubra	.24	1	A	2	3	1	2	Ms.	Meso.
Nyssa sylvatica	1.04	1	A	3	3	1	1	Mg.	Meso.
Ostrya virginiana	.64	1	A	2	3	1	2	Ms.	Meso.
Prunus serotina	.80	1	B	2	3	1	2	Ms.	Meso.
Psedera quinquefolia	56.92	2	E	4	3	2	3	Ch.	Meso.
Quercus alba	.20	1	A	2	3	1	1	Mg.	Meso.
Ribes cynosbati	.56	1	A	2	3	1	3	N.	Micro.
Rubus trivialis	.08	1	A	2	3	1	3	N.	Meso.
Sambucus canadensis	.04	1	A	2	3	2	3	N.	Micro.
Sassafras variifolium	.08	1	A	2	3	1	2	N.	Meso.
Smilax hispida	.04	1	A	2	3	1	3	N.	Meso.
Ulmus fulva	.96	1	A	2	3	4	1	Ms.	Meso.
Viburnum acerifolium	2.84	1	A	3	3	1	3	N.	Meso.
Vitis cordifolia	.12	1	A	2	3	2	3	N.	Meso.

noveboracense, Asplenium acrosticoides, Botrychium virginianum, Campanula americana, Carex (sp?), Caulophyllum thalictroides, Chenopodium album, Collinsonia canadensis, Epipactis pubescens, Erigenia bulbosa, Eupatorium urticæfolium, Hybanthus concolor, Isopyrum biternatum, Laportea canadensis, Medeola virginiana, Mitchella repens, Monotropa uniflora, Osmorrhiza claytoni, Panax quinquefolium, Phacelia bipinnatifida, Phegopteris hexagonoptera, Phlox divaricata, Phryma leptostachya, Pogonia trianthophora, Polygonatum biflorum, Polystichum acrosticoides, Prenanthes alba, Pyrola elliptica, Sanguinaria canadensis, Sanicula trifoliata, Solanum nigrum, Solidago cæsia, Stylophorum diphyllum, Tradescantia pilosa, Trillium declinatum, Urtica gracilis, Viola palmata, V. scabiuscula, V. sororia and *V. striata.*

SUMMARY AND DISCUSSION OF RESULTS IN FOUR-METER QUADRATS

Table II gives the complete statistical summary for the woody species below two inches diameter which were considered in the four-meter quadrats.

The twenty-six species of woody plants here considered make up 70 per cent. of the total of thirty-nine woody plants in the entire area of the association, but there was no attempt made to differentiate between plants above and below two inches diameter in the total area list.

The total density for the twenty-five quadrats is 107.40 plants per 16 square meters. The species of greatest density was *Psedera quinquefolia* (56.92), which in some places was so dense that it was almost impossible to count. Since it reproduces vegetatively by means of stolons, each young rooted shoot was considered a separate plant. *Sambucus canadensis* and *Smilax hispida* were equally low in density, only one plant of each being found in the total twenty-five quadrats.

Crown coverage was considered the basis of determining the classes of dominance. Only two species covered more than 5 per cent. of the quadrat area, *viz., Acer saccharum* and *Psedera quinquefolia.* Because of the spreading of the branches, *Acer saccharum* covered from 6-25 per cent. of the area, and *Psedera quinquefolia,* although smaller in size, reached the same class because of the large number of individual plants found—a total of 1,422 plants.

Acer saccharum was found in each of the four-meter quadrats and therefore had a frequency of 100 per cent., putting it in Class E.

Psedera quinquefolia was also in Class E but had a frequency per cent. of only 84. There were no species in Class D, but there were three in Class B and eighteen in Class A. There is no direct obligate relationship between dominance and frequence, but it is interesting to note that in these quadrats *Acer saccharum* was highest in both dominance and frequence.

Approximately 77 per cent. of the species had a sociability of 2, appearing in small groups. Nineteen per cent. of them were in Class 3 and 4 per cent. in Class 4. *Psedera quinquefolia* was in Class 4 of sociability and also of greatest density in the four-meter quadrats, which seems to be a logical correlation.

All the plants had a vitality of Class 3, indicating that they all were normal in both vegetative and reproductive functions. The vernal aspect of the beech-maple association was further brought out in the fact that approximately 77 per cent. of the woody species below two inches in diameter flowered during the spring season. Nineteen per cent. flowered during the summer and only one plant, *Ulmus fulva*, flowered during the winter season. None of the species were autumnal in flowering.

Since herbaceous plants were not considered in these sample areas, only three classes of stratification appear. Class 1 included trees above thirty-five feet in height; Class 2 were trees below thirty-five feet, and Class 3 included all shrubs and vines regardless of height. Vines may be classed according to the height they attain, but were combined with the shrubs in this study. About 35 per cent. of the species were in Class 1, 27 per cent. in Class 2 and 38 per cent. in Class 3.

The spectrum for percentages of each life-form class in the total number of four-meter quadrats is here given:

LIFE-FORM CLASSES	PER CENT. FOUR-METER QUADRATS
Phanerophyte—	
Nanophanerophyte	34
Microphanerophyte	8
Mesophanerophyte	31
Megaphanerophyte	19
Chamæphyte	8

Due to the fact that herbaceous plants were not considered in the four-meter quadrats, there was less variation in leaf sizes than in the one-meter quadrats. Approximately 88 per cent. of the species were mesophylls and the other 12 per cent. were microphylls. The mesophyllous character shows a direct correlation with the climate.

The following woody species appeared in the entire area but not in any of the quadrats: *Acer negundo*, *Æsculus glabra*, *Benzoin æstivale*, *Cornus alternifolia*, *Evonymus atropurpureus*, *Hydrangea arborescens*, *Juglans cinerea*, *Rhus toxicodendron*, *Rubus occidentalis*, *Tilia americana* and *Tsuga canadensis*.

TABLE III. SOCIOLOGICAL SUMMARY OF SPECIES OCCURRING IN TEN-METER QUADRATS

CONCEPTS RELATING TO SPECIES COMPOSING A PLANT COMMUNITY

FLORISTIC LIST WOODY PLANTS MORE THAN TWO INCHES IN DIAMETER	I ORGANIZATION							II SYN-ECOLOGY	
	ANALYTIC								
	Quantitative			Qualitative					
SPECIES	a. DENSITY	b. DOMINANCE (Classes 1-5)	c. FREQUENCE (Classes 1-5, A-E)	a. SOCIABILITY (Classes 1-5)	b. VITALITY (Classes 1-3)	c. PERIODICITY (Classes 1-4)	d. STRATIFICATION (Classes 1-5)	a. LIFE FORM (Classes 1-10)	b. LEAF SIZE (Classes 1-6)
Acer saccharum	1.60	2	D	3	3	1	1	Ms.	Meso.
Carpinus caroliniana	.20	1	A	2	3	1	2	Ms.	Meso.
Carya cordiformis	.08	1	A	2	3	1	1	Ms.	Meso.
Carya ovata	.04	1	A	2	3	1	1	Ms.	Meso.
Celtis occidentalis	.04	1	A	1	3	1	1	Ms.	Meso.
Cornus florida	.12	1	A	2	3	1	2	Ms.	Meso.
Fagus grandifolia	1.48	3	E	3	3	1	1	Mg.	Meso.
Fraxinus lanceolata	.08	1	A	2	3	1	2	Ms.	Meso.
Ostrya virginiana	.36	1	A	2	3	1	2	Ms.	Meso.
Quercus alba	.08	1	A	2	3	1	1	Mg.	Meso.
Quercus muhlenbergii	.04	1	A	2	3	1	1	Mg.	Meso.
Ulmus fulva	.12	1	A	2	3	4	1	Ms.	Meso.

SUMMARY AND DISCUSSION OF RESULTS IN TEN-METER QUADRATS

Table III shows the complete statistical summary for the woody species above two inches diameter which were considered in the twenty-five ten-meter quadrats.

In the ten-meter quadrats there was a total of forty individuals of *Acer saccharum* and thirty-seven of *Fagus grandifolia* above two inches in diameter. This is in marked contrast to the four-meter quadrats, where there were 399 individuals of *Acer saccharum* and only twenty-eight of *Fagus grandifolia* below two inches in diameter. At the first glance at these figures, it would seem that *Acer saccharum* is fast supplanting instead of being a codominant with *Fagus grandifolia*. However, the results of only one season's work are insufficient for such a conclusion. There was a very abundant crop of beechnuts this season which may cause the figures to be entirely reversed in a few years. Also, there may be a greater mortality among beech seedlings than maple, and there may be a greater mortality among the maples at a later stage of development than there is among the beeches. Although there were a few less beeches than maples in the ten-meter quadrats, in a general survey of the entire area it was apparent that there were more large beech trees than large maples. The diameter measurements showed that the beeches were also much larger than the maples. This is shown in the chart giving the diameter breast-high measurements of the trees considered in the ten-meter quadrats. The largest trees of the area are the white oaks, *Quercus alba,* but only one medium-sized individual appeared in the quadrats. The white oak is not reproducing itself, since it was absent from the seedling and sapling flora. This does not prejudice its Class 3 vitality but its competition ability under beech-maple dominance. It would seem that *Quercus alba* had been dominant many years ago and is now practically replaced by *Fagus grandifolia*, which, in turn, may be replaced by *Acer saccharum,* since the latter is more important at present in the lower strata.

The density of *Acer saccharum*, 1.6 plants per ten-meter quadrat, is slightly higher than that of *Fagus grandifolia* which has a density of 1.48. The difference in the size of the two species is shown by the dominance figures, which are based on the extent of crown coverage. *Fagus grandifolia* has a dominance of Class 3, covering 26-50 per cent. of the area, and *Acer saccharum* is in Class 2, covering only 5-25 per cent. of the area of the twenty-five ten-meter quadrats.

It is interesting to note that *Fagus grandifolia* is higher than *Acer saccharum* in both dominance and frequence. *Fagus grandifolia* is in Class E of frequence, appearing in 84 per cent. of the twenty-five ten-meter quadrats, while *Acer saccharum* is in Class D, for it appears in only 68 per cent. of the quadrats. Raunkiaer (see Smith (7) and Fuller and Bakke (5), in Europe, and Kenoyer (6)), in America, made exten-

TABLE IV. DBH CLASSES OF TREES IN TEN-METER QUADRATS

CLASSES DBH	ACER SACCHARUM	CARPINUS CAROLINIANA	CARYA CORDIFORMIS	CARYA OVATA	CELTIS OCCIDENTALIS	CORNUS FLORIDA	FAGUS GRANDIFOLIA	FRAXINUS LANCEOLATA	OSTRYA VIRGINIANA	QUERCUS ALBA	QUERCUS MUHLENBERGII
2	23	5	1		1	3	10		3		
4	12						3	1	4		1
6			1					1	3		
8	1						1				
10							5			1	1
12	1						1				
14							3				
16							3				
18							3				
20							3				
22				1			1				
24							1				
26							2				
28											
30							1				

sive quadrat studies, and, on the basis of the results, gave numerical values to the various frequency classes. For the purpose of comparison, these are given in tabular form with the frequency percentages for the three sizes of quadrats in the present study.

AUTHOR	LOCATION AND NO. OF PERCENTAGES INVOLVED	PER CENT. IN FREQUENCY CLASSES A	B	C	D	E
Raunkiaer	European, 8,087	53	14	9	8	16
Kenoyer	American, 1,425	69	12	6	4	9
This Study	25 One-meter Quadrats	82	6	6	3	3
This Study	25 Four-Meter Quadrats	69	12	12	0	7
This Study	25 Ten-Meter Quadrats	84	0	0	8	8

As in the case of the one- and four-meter quadrats, the majority of species considered in the ten-meter quadrats were in Class 2 of sociability. All species were in Class 3 of vitality, performing all normal functions, and all were vernal in respect to flowering period.

Eight of the twelve species above two inches diameter were in the tall tree stratum, above thirty-five feet in height, and the other four were in the short tree stratum, below thirty-five feet. Only two life forms were exhibited, 75 per cent. of the species being in the Mesophanerophyte class and 25 per cent. in the Megaphanerophyte class. All twelve species were mesophyllous in leaf size.

SUMMARY OF RESULTS

ONE-METER QUADRATS. The total number of herbaceous species in the twenty-five one-meter quadrats was thirty-two, approximately 43 per cent. of the number of species in the entire area covered by the association. *Dicentra canadensis* was the species of highest density and dominance, but *Erythronium americanum* was highest in frequence. Seventy-five per cent. of the species were in Class 2 of sociability and the rest in Classes 3 and 4. All plants exhibited a vitality of Class 3 except *Podophyllum peltatum,* which was in Class 2. All species flowered during the spring or summer and 12 per cent. flowered during both seasons. Only herbaceous plants were studied in the one-meter quadrats, so all were in Class 4 of stratification. Hemicryptophytic forms predominated, with geophytes second and therophytes next in importance. Microphyll and mesophyll leaf sizes were clearly dominant over the other sizes exhibited.

FOUR-METER QUADRATS. The twenty-six species of woody plants below two inches in diameter make up about 70 per cent. of the total number of woody plants in the entire area of the association. *Psedera quinquefolia* was very high in density (56.92) and was equal to *Acer saccharum* in dominance. *Acer saccharum* had a frequency of 100 per cent., appearing in each of the twenty-five four-meter quadrats. *Psedera quinquefolia* was in the same class, E, but had a frequency of 84 per cent. Seventy per cent. of the species were in Class 2 of sociability and all species were in Class 3 of vitality. Seventy per cent. of the species flowered during the summer. Thirty-five per cent. were in Class 1 of stratification, 27 per cent. in Class 2 and 38 per cent. in Class 3. The majority of species were nanophanerophytic and mesophanerophytic in life form. Eighty-eight per cent. were mesophyllous in leaf size and the other 12 per cent. were microphyllous.

TEN-METER QUADRATS. *Acer saccharum* and *Fagus grandifolia* were approximately the same in density in the ten-meter quadrats, where only woody plants above two inches in diameter were considered, but *Ace saccharum* was slightly higher. *Fagus grandifolia* was the highes species in both dominance and frequency classes, with *Acer saccharum* second highest. The majority of species considered were in Class 2 of sociability and all were in Class 3 of vitality. All species were vernal in flowering period. Approximately 67 per cent. of the species were in the tall tree stratum, above thirty-five feet in height. Seventy-five per cent. were Mesophanerophytes and the other 25 per cent. were Megaphanerophytes. All twelve species considered were mesophyllous in leaf size.

GENERAL SUMMARY

Permanent quadrats have been located in a beech-maple association at Turkey Run State Park, where they are available for future study. During the period from early April until late November of 1931 the vegetation was studied in the quadrats to determine the density, dominance, frequence, sociability, vitality, periodicity, stratification, life forms and leaf sizes of all the species of Pteridophytes and Spermatophytes occurring there.

In the herbaceous stratum it was found that the species were essentially vernal and estival in character, with the early spring species highest in density, dominance and frequence. The predominance of hemicryptophytic life forms was found to be in agreement with previous studies of similar plant associations.

Since Turkey Run State Park is near the western limits for *Fagus grandifolia,* and because *Acer saccharum* and *Fagus grandifolia* have long been considered codominants in associations of this type, especial attention was paid to these two species. It was evident in the entire area and in the large quadrats where trees above two inches in diameter were considered that beech was higher in both coverage and frequence than maple, although maple was slightly higher in density. On an average basis, the beech trees were much larger than the maples and were clearly much older. In the four-meter quadrats, where seedlings and saplings under two inches in diameter were counted, a great difference was noted in the reproduction of the two species. In 1931 there were 399 individuals of *Acer saccharum* as contrasted to twenty-eight of *Fagus grandifolia.* Although the seedlings were not separated from the saplings in the total count, the great majority of these individuals were seedlings. The maples of sapling size far outnumbered the beeches of the same size. In 1932 a count was made of the beech and maple seedlings and saplings in the same area and the maples showed an even greater gain in the reproductive layer over the beeches. At this time there were 1433 maples and seventy-three beeches, most of these being seedlings. Although no definite conclusions may be drawn from a study of only two seasons, the evidence so far gained seems to show that *Acer saccharum* may be succeeding *Fagus grandifolia* in this area, instead of being codominant with it.

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BOOK REVIEWS

USEFUL PLANTS

Plant lovers and professional botanists as well will find pleasure in reading the new edition of Clute's "Useful Plants."[1] In addition to the information which one would expect from a perusal of the table of contents, which shows chapters on origin, sources and varieties of food plants; plants yielding materials used as condiments, perfumes, beverages, stimulants, textiles, dyes, soaps, tannins, gums, resins, rubbers, oils and fats; also on drug plants, wood products and decorative plants; it is refreshing to speculate with the author on the contributions study of plants yields toward knowledge of the history of civilization.—R. C. F.

BIOLOGY

Man as an individual and as a species is the center about which all the facts and principles of biology are made to radiate in the latest textbook on general biology by Wheat and Fitzpatrick.[2] The course departs entirely from the type method of teaching, centering all attention upon fundamental principles as such in their relation to man. The increased interest in science in our secondary schools and the demand for subject matte which has a vital relationship to human problems has also resulted in a recent laboratory guide which follows the same trend.[3] Part I of Hunter' new guide deals with the relation of living organisms to their surroundings; Part II with the part played by green plants; Part III with interrelations of plants and animals; Part IV with man as a organism; and Part V with man's relation to other organisms. The exercises are organized with the viewpoint that mental discipline supersedes factual content in educational value. Pupils are guided, in their handling of data, into the mos approved methods of presentation making for accuracy of observation efficiency of effort and precision of thought.—R. C. F.

[1] Clute, Willard N. Useful plants of the world. Pp. XIV-220. Indianapolis: W. N. Clute & C 1932.

[2] Wheat, Frank Merrill, and Elizabeth T. Fitzpatrick. General biology. Pp. VIII-566. Ne York: American Book Co. 1932.

[3] Hunter, George W. Laboratory problems in biology. Pp. 328. New York: American Book C 1932.